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Search Frictions, Efficiency Wages and Equilibrium Unemployment

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Abstract

This paper analyses the equilibrium unemployment rate in an alternative type of search frictions model in which efficiency wages replace the assumption of wage bargaining. We identify an important interaction between search frictions and efficiency wages that affects the optimal wage and through this affects the equilibrium unemployment rate. Calibrations of our model suggest that the equilibrium unemployment mainly reflects search frictions and interactions between search frictions and efficiency wage effects.

Keywords: efficiency wages, search frictions, equilibrium unemployment, labour market policy

JEL Classification: J3, J6

1 Introduction

Explaining unemployment is one of the central problems in economics. The currently dominant approach in the literature is the search frictions model (e.g. Diamond, 1982, Mortensen and Pissarides, 1999, Pissarides, 2000).

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This provides a simple framework for the analysis of the labour market and associated policy issues (eg, Royal Swedish Academy of Sciences, 2010). The search frictions model has two main elements. The first is a model of the imperfect matching of workers with jobs, explaining why unemployed workers coexist with unfilled vacancies. This is an essential part of the model. The second is a model of how the surpluses accruing to workers and firms from a job match are divided between the parties through bargaining over the real wage. This aspect of the model seems less essential. In the search frictions model, wage bargaining ensures that the real wage exceeds the marginal rate of substitution between consumption and leisure and thus explains the existence of involuntary unemployment. However, this is not the only way of doing this. A leading alternative to wage bargaining is efficiency wage theory: therefore, an alternative type of search frictions model can be obtained by combining imperfect matching with efficiency wages.

In this paper, we explore this alternative type of search frictions model. There is a small existing literature on this. Malcomson and Mavroeidis (2007) incorporate a Shapiro and Stiglitz (1984) no-shirking constraint into a search frictions model with wage bargaining, which they estimate using data for the US and UK; see also Zaharieva (2010). We take a different approach. We combine search frictions with a simple model of efficiency wages, similar to Solow (1979) and Summers (1984), in which output depends on the amount of effort expended by workers, which is in turn a function of the wage. Our analysis focuses on wage-setting and the determination of the equilibrium unemployment rate. We find that these have similar determinants: search frictions (eg the efficiency of job matching and the cost of posting vacancies) and factors relevant to efficiency wages (eg the responsiveness of effort to the wage). In existing search frictions models, wages and unemployment also reflect search frictions but also depend on the relative bargaining power and the reservation wage of workers¹.

We argue that there is an important interaction between search frictions and efficiency wages which affects the optimal wage decision of firms

¹The model used in Wesselbaum (2013) is broadly similar; however he develops a DSGE model and uses this to study the impact of macroeconomic shocks.

and through this affects the equilibrium unemployment rate. In this, as in other models with efficiency wages, output depends on effective labour, the product of employment and effort per worker. As Solow originally argued, firms maximise profit by minimising the cost of effective labour. The interactions between search frictions and efficiency wages arises because search frictions affect the optimal composition of effective labour. An increase in hiring costs due to search frictions leads the firm to reduce employment and increase its wage, leading to higher levels of effort.

We use standard values from the literature to parameterise our model. With these, the equilibrium rate of unemployment is 4.61% (close to the average unemployment in the US over recent decades). If there were no efficiency wage effects, our model would simplify to a search frictions model where firms set the wage unilaterally. In this case, the equilibrium unemployment rate would be 2.63% (the wage would be lower, equal to the reservation wage of workers). If there were no search frictions, our model would simplify to an efficiency wage model; in this case the equilibrium unemployment rate would be 4% (the wage would be higher, largely as a consequence of the lower unemployment rate).

We also decompose the equilibrium unemployment rate, keeping the real wage constant, into a component due to search frictions (3.57%), a component due to efficiency wages (0.14%) and a component that due to interactions between the two (0.90%). Thus, the interactions we found at the level of the firm have an important impact on the aggregate equilibrium unemployment rate.

The remainder of the paper is structured as follows. Section 2) analyses the optimal behaviour of households, our formulation here is similar to Danthine and Kurmann (2010). Section 3) analyses the optimal employment and wage-setting choices of firms. We obtain a simple generalisation of the well-known Solow (1979) Condition that reflects search frictions and from this show that the optimal wage reflects search frictions and efficiency wage effects. Section 4) analyses the equilibrium unemployment rate, showing how this reflects search and matching frictions, efficiency wage effects and interactions between them. Section 5) presents a calibration of our model.

Section 6) summarises and concludes.

2 Households

There is a continuum of identical households on the unit interval, each containing a continuum of identical individual members. We assume that each individual inelastically supplies one unit of labour in every time period; the household provides full unemployment insurance so all household members have the same level of consumption. Household members supply effort to the firm that employs them; they suffer no disutility from supplying what they perceive to be the "fair" level of effort. The utility of household j is

$$E_0 \sum_{k=0}^{\infty} \beta^k \{ \log(C(j)_{t+k}) - N(j)_{t+k} [e(j)_{t+k} - e^*(j)_{t+k}]^2 \} \quad (1)$$

where $C(j)$ and $e(j)$ denote consumption and effort, $N(j)$ is the fraction of household members who are employed and e^* is the perceived fair level of effort.

The budget constraint of the household is

$$C(j)_t + \frac{B(j)_t}{P_t} = \frac{W(j)_t}{P_t} N(j)_t + \omega(1 - N(j)_t) + (1 + i_{t-1}) \left(\frac{B(j)_{t-1}}{P_t} \right) + \Pi(j)_t \quad (2)$$

where B is the household's nominal holdings of one-period bonds, P is the aggregate price level, W is the nominal wage, ω are real unemployment benefits, i is the nominal interest rate paid on bonds, Π are real profits received by the household net of lump sum taxes.

The household chooses consumption, the amount of effort to supply and bond holdings to maximize (1) subject to (2). The optimality conditions include

$$\frac{1}{C(j)_t} = \beta E_t \frac{(1 + i_t)}{(1 + \pi_{t+1})} \frac{1}{C(j)_{t+1}}$$

and

$$e(j)_t = e^*(j)_t$$

where $\pi_t = \frac{P_t - P_{t-1}}{P_{t-1}}$ is the inflation rate.

2.1 The Fair Level of Effort

We assume that the fair level of effort depends on the proportional gap between the wage and a reference wage.

Assumption 1. Following Summers (1988), the fair level of effort at firm i is given by

$$e^*(w_{it}, \bar{w}_{it}) = \left(\frac{w_{it} - \bar{w}_{it}}{\bar{w}_{it}} \right)^\sigma \quad (3)$$

for $w_{it} > \bar{w}_{it}$ and $0 < \sigma < 1$, where $w_{it} = \frac{W_{it}}{P_{it}}$ is the real product wage of firm i , W_{it} is the nominal wage paid by firm i , P_{it} is the price set by firm i and \bar{w} is the real reference wage².

Assumption 2. The reference wage depends on factors external to firm i . Specifically

$$\bar{w}_{it} = (1 - U_t)w_t \quad (4)$$

where u is the unemployment rate and w_t is the average wage paid by other firms. We assume that $\bar{w}_{it} > b$; this ensures a positive level of output.

We define the elasticity of effort with respect to the real wage at the firm as $\varepsilon_{it} = \frac{w_{it} e_{w_{it}}(w_{it}, \bar{w}_{it})}{e_{it}}$. Given Assumption 1, ε_{it} can be written as

$$\varepsilon_{it} = \frac{\sigma w_{it}}{w_{it} - \bar{w}_{it}} \quad (5)$$

²This is expressed in terms of the real product wage $\frac{W_{it}}{P_{it}}$ rather than the real consumption wage relevant to workers, $\frac{W_{it}}{P_t}$. If we express effort as a function of the real consumption wage, ie $e^* = \left(\frac{\frac{W_{it}}{P_t} - \frac{\bar{W}_{it}}{P_t}}{\frac{\bar{W}_{it}}{P_t}} \right)^\sigma$, where \bar{W}_{it} is the nominal reference wage, we can obtain (3) by multiplying numerator and denominator by $\frac{P_t}{P_{it}}$.

3 Firms

There are two types of firms. Imperfectly competitive intermediate goods firms hire labour and use this to produce intermediate goods. These are purchased by competitive final goods firms who use them to produce final consumption goods which are sold to households.

3.1 Final Goods Firms

The production function for final goods is

$$Y_t = [\int_0^1 Y(i)_t^{(\theta-1)/\theta} di]^{\theta/(\theta-1)}, \theta > 1$$

where $Y(i)$ denotes intermediate good k . Each final goods firm chooses intermediate good inputs in order to minimise its cost $\int_0^1 P(i)_t Y(i)_t di$ subject to $[\int_0^1 Y(i)_t^{(\theta-1)/\theta} di]^{\theta/(\theta-1)} \geq Y_t$ where $P(i)_t$ is the price of intermediate good i . The implied demand for intermediate good i can then be written as

$$Y(i)_t = \left(\frac{P(i)_t}{P_t} \right)^{-\theta} Y_t$$

where $P_t = [\int_0^1 P(i)_t^{1-\theta} di]^{1/(1-\theta)}$

3.2 Intermediate Goods Firms

Assumption 3. The production function for an intermediate goods firm is³

$$Y(i)_t = A_t e(i)_t N(i)_t \tag{6}$$

where A_t is total factor productivity, $e(i)$ is effort at firm i and $N(i)$ is employment at firm i ; $e(i)N(i)$ is thus effective labour input. We assume $A_t = A\sigma_t$ where σ is a productivity shock and that unemployment benefits are indexed to average total factor productivity, $\omega = Ab$.

³The assumption of constant returns to scale simplifies but does not qualitatively affect the results derived below.

3.3 The Labour Market

Employment evolves according to

$$N_{it} = (1 - \tau)N_{it-1} + h_{it} \quad (7)$$

where h is the number of workers hired and τ is the exogenous job separation rate. The labour market is characterised by search frictions and so firms must post vacancies in order to hire workers. Aggregate hiring is determined by the matching function $h_t = M(U_t, V_t)$ where $M'(\cdot) > 0$, $M''(\cdot) \leq 0$, h are aggregate hires, U is the number of job seekers and V are aggregate vacancies. We assume the matching function has constant returns to scale, so $h_t = V_t M(\frac{U_t}{V_t}, 1)$, hence the aggregate vacancy filling rate q_t is given by $q_t = \frac{h_t}{V_t} = \bar{M}(\frac{U_t}{V_t})$, where $\bar{M}(\frac{U}{V}) = M(\frac{U}{V}, 1)$. We define the vacancy filling rate for firm i as $q_{it} = \frac{h_{it}}{V_{it}}$. We assume that the number of workers hired by firm i is proportional to the relative number of vacancies it posts, so $h_{it} = \frac{V_{it}}{V_t} h_t$. As a result, $q_{it} = q_t$ and so the vacancy filling rate is exogenous at the level of firm⁴. We assume that the real unit cost of posting a vacancy is proportional to total factor productivity, so $\frac{\gamma_{it}}{P_{it}} = \bar{\gamma}A_t$, where γ_{it} is the nominal cost of posting a vacancy.

3.4 Optimal Wages and Employment

Per-period profit for intermediate firm i is

$$\pi_{it}^I = P_{it}Y_{it} - W_{it}N_{it} - \gamma_{it}V_{it}$$

where W_{it} is the nominal wage. In an efficiency wage context, the firm chooses employment and the wage subject to the production function, the effort function, the relationship between vacancies and employment and the constraint $W_{it} \geq b$.

⁴We follow the literature and assume that firms seek to hire in every period.

The first-order condition for employment is

$$\frac{P_{it}}{\mu} A_t e_{it} = W_{it} + \gamma_{it} \frac{A_t}{q_{it}} - (1 - \tau) E_t \delta_{t+1} \frac{\gamma_{it+1} A_{t+1}}{q_{it+1}}$$

where $\mu = \frac{\theta}{\theta-1}$ is the mark-up of price over marginal cost and $\delta_{t+1} = \beta E_t \frac{C_t}{C_{t+1}}$ is the stochastic discount factor. This equates the marginal revenue generated by an increase in employment to the marginal cost of a new hire, composed of the wage plus marginal hiring costs, i.e the cost of hiring an additional worker in the current period less the expected present value of the reduction in next period hiring costs implied by this. We can express this as

$$\frac{1}{\mu} A_t e_{it} = w_{it} + \lambda_{it} \quad (8)$$

where, $\lambda_{it} = \bar{\gamma} \left\{ \frac{A_t}{q_{it}} - (1 - \tau) E_t \delta_{t+1} \frac{(1 + \pi_{t+1}) A_{t+1}}{q_{it+1}} \right\}$ is the real cost of hiring an additional worker.

The first-order condition for the nominal wage is

$$\frac{1}{\mu} A_t N_{it} e_{w_{it}} \leq N_{it} + \phi_{it}$$

$$W_{it} \geq b$$

and

$$\phi_{it}(W_{it} - b) = 0, \phi_{it} \geq 0$$

where ϕ is the multiplier on this constraint. If there are efficiency wage effects, the firm will set $w_{it} > \bar{w}_{it}$. Since $\bar{w}_{it} > b$ this implies $\phi_{it} = 0$ ⁵. The first-order condition for the nominal wage can then be written as

$$\frac{1}{\mu} A_t e_{w_{it}} = 1 \quad (9)$$

Dividing (9) by (8), we obtain

⁵The constraint $w_{it} \geq b$ is thus only relevant in a pure search frictions model (a case we return to in section 4.3 below).

Proposition 1) The optimality conditions for employment and the wage imply

$$\varepsilon_{it} = \frac{w_{it}}{w_{it} + \lambda_{it}} \quad (10)$$

At the optimum, the elasticity of effort with respect to the wage equals the ratio of the wage to the present value of the marginal cost of a new hire. Combining Proposition 1) with equation (5), we obtain

Proposition 2) The optimal wage for the firm is

$$w_{it} = \frac{1}{1 - \sigma} \bar{w}_{it} + \frac{\sigma}{1 - \sigma} \lambda_{it} \quad (11)$$

The wage has two distinct components. The first is a pure efficiency wage effect in which the wage is a mark-up over the reference wage, where the mark-up reflects the strength of efficiency wages. The second reflects labour market frictions as the worker receives a proportion of hiring costs, where this proportion also reflects the strength of efficiency wage effects. This wage equation reflects an interaction between search frictions and efficiency wage effects. For example, an increase in the cost of posting a vacancy (γ) increases λ_{it} and implies reduced employment and increased wages, leading to increased effort. Therefore search frictions affect the optimal composition of effective labour. This interaction between search frictions and efficiency wage effects will be reflected in the equation for the equilibrium unemployment rate derived below.

The wage equation in (11) has interesting parallels with wage equations derived in models with search frictions e.g. Pissarides (2000). In both, the wage is an increasing function of search costs, but for different reasons. In a search frictions model, higher search costs increase the surplus from a job match. Since the wage bargain divides this surplus between workers and the firm, this is reflected in a higher wage⁶. In a model with search frictions and efficiency wages, by contrast, higher search costs induce firms

⁶In a search frictions model, the surplus also reflects the value of employment to a worker. This aspect is irrelevant in this paper as the firm chooses the wage unilaterally.

to adjust the composition of effective labour by increasing effort and reducing employment, something that requires an increase in the wage. In (11), the wage also depends on efficiency wages; this effect is not present in the search frictions literature.

Propositions 1) and 2) extend results in the existing efficiency wage literature. The expression in (10) simplifies to the original Solow (1979) condition if there are no search costs. The first term in the wage equation in (11) is similar to expressions in Summers (1988) and Romer (2011). The second term in (11) extends these by adding a component that reflects labour market search⁷. Following Solow (1979), we can interpret these results as the outcome of minimization of the cost of effective labour. In this model, the cost of effective labour is $(w_{it} + \lambda_{it})/e_{it}$; minimising this implies

$$\frac{e_{w_{it}}(w_{it} + \lambda_{it})}{e_{it}} = 1$$

or

$$\varepsilon_{it}(1 + \frac{\lambda_{it}}{w_{it}}) = 1$$

from which we can derive the modified Solow Condition in Proposition 1).

4 Equilibrium Unemployment

We impose the equilibrium conditions $\varepsilon_{it} = \varepsilon$, $h_{it} = h$, $N_{it} = N$, $\lambda_{it} = \lambda$, $h = qN$, and $U_t = U$, where U is the equilibrium unemployment rate. We also impose

$$w_{it} = w_t = w \tag{12}$$

The aggregate first-order conditions for the wage and employment in steady state can be expressed as

$$\frac{Ae_w}{\mu} = 1 \tag{13}$$

⁷if there are no search costs, (11) simplifies to equation (10.15) in Romer (2011)

and

$$\frac{1}{\mu} Ae = w + \lambda \quad (14)$$

Combining these, we obtain an implicit expression for the equilibrium unemployment rate, given by

$$eq(1 - \varepsilon) = \mu \hat{\gamma} \quad (15)$$

Combining (4) and (12) implies $\frac{w - \bar{w}}{\bar{w}} = (\frac{U}{1 - U})$, so effort is given by

$$e = (\frac{U}{1 - U})^\sigma \quad (16)$$

while combining (4), (11) and (12) implies the wage is determined by

$$w = \frac{\sigma \lambda}{U - \sigma}$$

Combining this with (10) gives

$$1 - \varepsilon = (\frac{U - \sigma}{U}) \quad (17)$$

We assume the matching function is $M(U_t, V_t) = mU_t^\alpha V_t^{1-\alpha}$; this implies that the vacancy filling rate is

$$q(U) = m(\frac{mU}{\tau(1 - U)})^{\frac{\alpha}{1-\alpha}} \quad (18)$$

Substituting (16), (17) and (18) into (15), we obtain an expression for the equilibrium unemployment rate.

Proposition 3) The equilibrium unemployment is determined by the following implicit function

$$(\frac{U}{1 - U})^{\frac{\alpha + \sigma(1 - \alpha)}{1 - \alpha}} (\frac{U - \sigma}{U}) = \frac{\hat{\gamma} \mu \tau^{\frac{\alpha}{1 - \alpha}}}{m^{\frac{1}{1 - \alpha}}} \quad (19)$$

In (19), the unemployment rate is an increasing function of the mark-up (μ),

the responsiveness of effort to the wage (σ), the separation rate (τ), vacancy costs ($\hat{\gamma}$); and a decreasing function of the efficiency of job matching (m).

Next we consider the unemployment rates implied by a pure efficiency wage model and a pure search frictions model.

4.1 Search Frictions Model

If there are no efficiency wage effects ($\sigma = 0$), the model becomes a search frictions model in which the wage is unilaterally set by the firm. In this case, the constraint on wages binds and so $w = b$. Combining this with the optimality condition for employment and aggregating, the equilibrium unemployment rate in a search frictions model (U^{sf}) is determined by the condition

$$\frac{1}{\mu} = b + \frac{\hat{\gamma}}{q(U^{sf})} \quad (20)$$

This implies⁸

$$U^{sf} = \frac{\tau}{\tau + m^{\frac{1}{\alpha}} \left(\frac{1-\mu b}{\mu \hat{\gamma}} \right)^{\frac{1-\alpha}{\alpha}}} \quad (21)$$

4.2 Efficiency Wage Model

If there are no labour market frictions ($\hat{\gamma} = 0$), the model becomes an efficiency wage model. If so, (10) simplifies to the familiar Solow Condition, $\varepsilon = 1$. From (17), this implies

$$U^{ew} = \sigma \quad (22)$$

where U^{ew} is the unemployment rate in an efficiency wage model.

⁸Similar expressions for equilibrium unemployment can be obtained in models with search frictions in which the bargaining power of workers tends to zero (eg Pissarides, 2000).

4.3 The Equilibrium Unemployment Rate

Combining (19) and (21) shows that

$$\frac{\hat{\gamma}\mu\tau^{\frac{\alpha}{1-\alpha}}}{m^{\frac{1}{1-\alpha}}} = (1 - \mu b)\left(\frac{U^{sf}}{1 - U^{sf}}\right)^{\frac{\alpha}{1-\alpha}} \quad (23)$$

Substituting (22) and (23) into (19) and rearranging, we obtain

Proposition 4) The equilibrium unemployment rate satisfies the following implicit relationship

$$U = \frac{\chi}{1 + \chi} \quad (24)$$

where

$$\chi = \left\{ \frac{1}{(1 - \mu b)} \left(\frac{U^{sf}}{1 - U^{sf}} \right)^{\frac{\alpha}{1-\alpha}} \left(\frac{U}{U - U^{ew}} \right) \right\}^{\frac{1-\alpha}{\alpha + \sigma(1-\alpha)}} \quad (25)$$

The equilibrium unemployment rate is therefore an increasing function of the unemployment rates implied by search frictions and efficiency wage models.

4.4 Interpretation

The determination of the equilibrium unemployment rate is illustrated in Figure 1). The optimality condition for the real wage in (13) is depicted as the downward-sloping "wage" curve, while the optimality condition for employment in (14) is depicted as the upward-sloping "employment" curve. The intersection of these curves at point *A* determines the equilibrium unemployment rate.

In the special case of a search frictions model, the optimality condition for employment, (20) is depicted as the "employment search frictions model" curve. Employers set the wage equal to unemployment benefits, depicted as the "benefits" curve. Intersection of the "employment search frictions model" and "benefits" curves at point *B* determines the equilibrium unemployment rate in a pure search frictions model. In the other special case of an efficiency wage model, the optimality condition for employment, given by (14), but where $\lambda = 0$, is depicted as the "employment efficiency wage

model" curve. Intersection of this with the wage curve at point C determines the unemployment rate in an efficiency wage model. Inspection of Figure 1) shows that the unemployment rate is lower in either of these special cases.

5 Calibration and Simulation Results

5.1 Calibration

We set the discount factor β equal to 0.988 (Shimer, 2005). The job separation rate is set as $\tau = 0.12$ (Gali, 2011, and Christiano et al, 2013). Following Shimer (2005), we assume that the parameters of the matching function are $\alpha = 0.72$ and $m = 1.355$. We assume the cost of posting a vacancy is $\bar{\gamma} = 0.213$. These assumptions imply that hiring costs are equivalent to 0.7% of annual output⁹. We assume the price markup is $\mu = 1.2$ a common value in the New Keynesian literature (eg Gali, 2008). For unemployment benefits, we assume $b = 0.4$. We also assume total factor productivity is $A = 1$. These assumptions imply that unemployment compensation is 60% of wage income in our simulations. We calibrate σ to give values for the equilibrium unemployment rate and the job finding rate that match post-war U.S. data; doing so we obtained $\sigma = 0.04$. Table 1) summarises the parameter values used in our calibration of the model.

Table 1) Calibration Parameters

β	α	m	$\bar{\gamma}$	τ	μ	σ	b
0.988	0.720	1.355	0.213	0.120	1.200	0.04	0.4

5.2 Simulation Results

These calibrated parameters imply that the equilibrium unemployment rate is $U = 4.61\%$ and the job finding rate is $f = 71\%$. The unemployment rate in a search frictions model is $U^{sf} = 2.63\%$ while the unemployment rate in an efficiency wage model is $U^{ew} = 4\%$.

Table 2) Simulation Results

⁹Gali (2011) assumes 0.1% while Christiano et al (2013) assume 1%

U	U^{sf}	U^{ew}	w	f
4.61%	2.63%	4.00%	0.64	71%

These simulations show that the unemployment rate would fall to 2.63% if efficiency wage effects were eliminated and would fall to 4% if search frictions were eliminated. We can also consider the decomposition of the unemployment rate of 4.61% into components due to search frictions, to efficiency wages and to interactions between search frictions and efficiency wages. To determine the component due to search frictions, consider point D in figure 1). At this point, the wage is fixed at $w = 0.64$ but employment is determined by the "employment search frictions model" relationship in (20). The unemployment rate at point D therefore represents the rate of unemployment in a search frictions model, at this wage. This value of unemployment is 3.57%. To determine the component due to efficiency wages, consider point E in figure 1). At this point, the wage is again fixed at $w = 0.64$ but employment is determined by the "employment efficiency wage model" relationship. The unemployment rate at point E therefore represents the rate of unemployment in an efficiency wage model, at this wage. This value of unemployment is 0.14%. The component of unemployment due to interactions between search frictions and efficiency wages is therefore $4.61\% - 3.57\% - 0.14\% = 0.9\%$. This exercise shows that the largest component of unemployment reflects the impact of search frictions but that interactions between search frictions and efficiency wage effects are also important. Table 3) summarises these findings

Table 3) Decomposition of Equilibrium Unemployment Rate

Equilibrium Unemployment Rate	of which: component due to		
	search frictions	efficiency wages	interactions
4.61%	3.57%	0.14%	0.90%

These interactions imply that a change in search frictions will lead to a smaller change in the equilibrium unemployment rate than it would in a search frictions model. Consider, for example, a reduction in the matching

efficiency parameter, m , from 1.355 to 1. If the wage is fixed at $w = 0.64$, in a pure search frictions model, the unemployment rate would increase by 1.77% (from 3.57% to 5.34%). By contrast, in our model the unemployment rate would increase by 0.77% (from 4.61% to 5.38%). This more muted effect arises because of the impact of increased search frictions on unemployment is partially offset by a reduction in the wage that occurs because the increase in unemployment reduces the reference wage.

Interactions between search frictions and efficiency wage effects have policy implications. The literature on search frictions has considered hiring subsidies to firms which reduce the cost of posting a vacancy (Pissarides, 2001). These subsidies have a smaller impact on the unemployment rate in the model outlined above than in a search frictions model. Consider for example a hiring subsidy which reduces $\bar{\gamma}$ from 0.213 to 0.13. If the wage is fixed at $w = 0.64$, in a pure search frictions model, this would reduce the unemployment rate by 0.61% (from 3.57% to 2.96%). However, in the model outlined in this paper, the reduction in the unemployment rate is only 0.17% (from 4.61% to 4.44%). A hiring subsidy reduces the unemployment rate by inducing firms to post more vacancies. When there are efficiency wages, this is partially offset by a reduction in vacancies due to the increase in the wage that results from the increase in the reference wage caused by lower unemployment.

6 Conclusion

In this paper we have developed an alternative type of search frictions model that combines a generic representation of efficiency wage effects with search and matching frictions. We have derived a simple generalisation of the Solow Condition, which we used to express the wage as the sum of components reflecting search frictions and efficiency wages. The impact of search frictions on wages is similar to existing search frictions models, which assume wage bargaining rather than efficiency wages, but our analysis differs

from these latter models by also including the impact of efficiency wage effects. We identified an interaction between search frictions and efficiency wages, through which increased search costs shifted the composition of effective labour input towards increased effort per worker and lower employment. This interaction was reflected in the equilibrium unemployment rate. We calibrated the model so that the equilibrium unemployment rate mimics the average unemployment rate in the US in recent decades. Decomposing the equilibrium unemployment rate into its' constituent parts, we found that search frictions accounted for the largest part of the unemployment rate but that the interaction effect was also numerically significant.

We would argue that our results are interesting but not definitive. We would wish to develop our work, in two main directions. First, we have replaced wage bargaining with efficiency wages; the logical next step is to combine both in the same model and analyse interactions between them. Second, a natural extension of our work would analyse the decomposition of unemployment away from equilibrium steady-state. We hope to address these issues in future work.

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